

Social impact of renewable energy systems: solar energy system in vulnerable community case study

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ABSTRACT

Photovoltaic lighting systems are unable to reach people with low purchasing power due to high installation costs, so they have traditionally been concentrated in families with high purchasing power and currently do not take into account the social power that this type of system represents. This article analyzes through bibliometric review the effect that lighting can have on human development and how a good lighting system can positively affect a community environment. It is proposed the social design of a photovoltaic lighting system which will be installed in a vulnerable community with resources obtained by the community itself and the whole process of accompaniment achieving a satisfactory impact on the community and achieving integration between the same from community participation. The development of workshops with the children of the community has also been proposed, leading to the training and recognition of alternative energy systems as a strategy of social appropriation.

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1. INTRODUCTION

The illumination of the environments where people live together becomes especially important when considering the effects, both positive and negative, that it can have on sharing. In relation to the above, there are studies such as those conducted by [1]-[3], which claim that lighting can produce positive effects on human moods, as well as provide economic, social and health benefits, energy efficiency and visual comfort. On the other hand, at the level of coexistence in [4] it is affirmed that the illumination impacts some psychological and physiological aspects like the arousal, the stress or the relaxation that are directly related to the violence, it is so, the illumination impacts positively the perception of security of the people, and studies like the one carried out by [5] has shown how the absence of lighting in common areas, in the case of Grohon's study in parks, creates an atmosphere of insecurity that leads to the community not using these spaces. The non-use of the spaces allows outsiders to misappropriate them to generate criminal acts. Based on the above, this article presents the development of a solar lighting system, which is implemented in some residential units located in the city of Manizales, Colombia, so that the inhabitants can reappropriate these spaces, giving them a new meaning. The option of a solar lighting system represents a social benefit at an economic level [6]-[10], as presented by [11] who indicates that in addition to the mentioned benefit, these

systems generate social impact at the level of security, improving the lifestyle of women, providing ecological light without pollution, improving the standard of living and the social situation.

The above are not the only authors who have worked on the social impact of lighting, so that, in order to generate an overview of publications worldwide related to the subject of this article, an exploratory bibliometric analysis has been carried out which allows the determination of the main key words related to lighting. Figures 1 and 2 show the cluster analysis developed in the VOSviewer software [12].

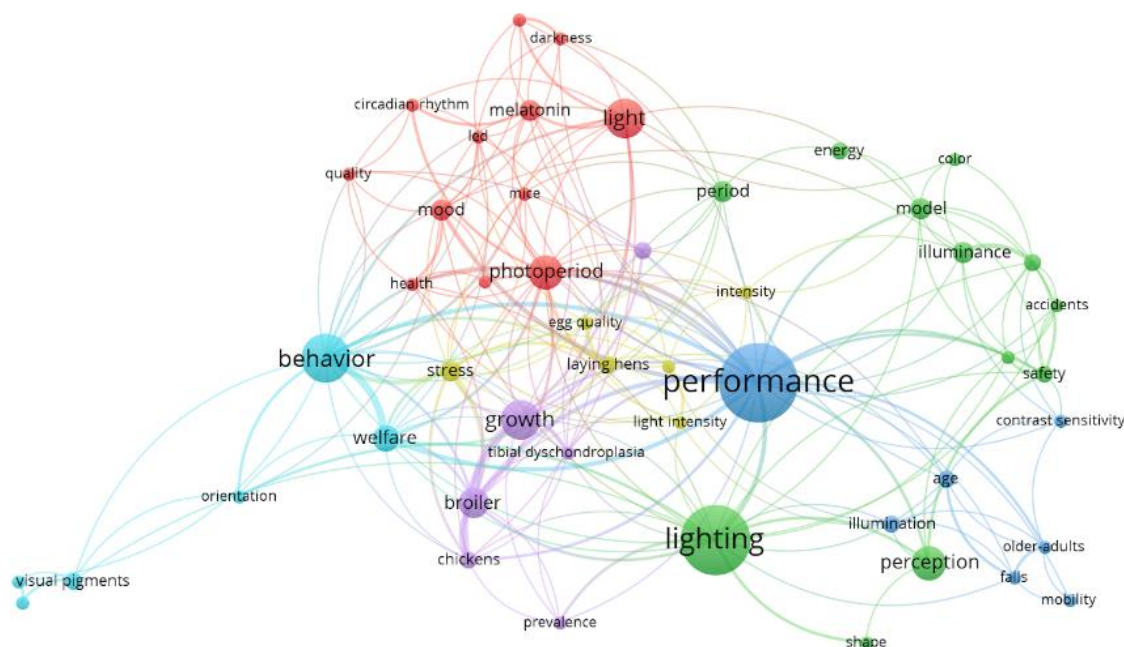


Figure 1. Co-occurrence analysis of all keywords ("effects of lighting")

The network presented in Figure 1, allows to establish that effectively the illumination can be related to the following keywords; performance, behavior, perception. The key word "behavior" is relevant to a study that aims to analyze the social impact of lighting, since as presented above, this is a human and social factor that is influenced by lighting. On the other hand, given the environment where the present study is applied, an analysis of the relationship between lighting and poverty is carried out. This analysis yields interesting results in terms of electrification, renewable energies, access to energy, development of cities and several references to alternative energies. Figure 2 shows the strong relationship between poverty and renewable energy systems, which provides the theoretical basis for this article to design a solar lighting system for a poor community, which is described in the case study.

Among the main authors we can mention Bouzarovski and Petrova [13] Those who raise the premise that all forms of energy and fuel poverty, in both developed and developing countries, are based on a common condition: the inability to achieve a level of socially and materially necessary household energy services. They further argue that domestic energy deprivation in its different forms and ways is fundamentally linked to the inefficient functioning of the socio-technical pathways that allow the satisfaction of domestic energy needs within which lighting is listed. For his part Elvidge and others [14] have associated the poverty index of a country by its levels of illumination from satellite images, which allows us to conclude how strongly these two aspects are related. Kanagawa and Nakata argue that recently, the multidimensional aspects of poverty, for example, the economy, education and health, have received increasing attention, and access to modern energy, such as electricity, is one possible solution to the problems in these aspects [15].

Education, besides being a human activity is a possibility to recognize ourselves as subjects in a diverse world [16]. The recognition of the subject, the citizen can be the greatest wealth of a community or a region [17], the work allowed to make a sociocultural recognition and to be approached it was supported in educational and pedagogical practices with the purpose of building interrelations. The educational practice in this sense is configured as the possibility for the coexistence in the School, which is understood as the great social and cultural system where formation and integration processes are achieved as subjects in a complex world [18].

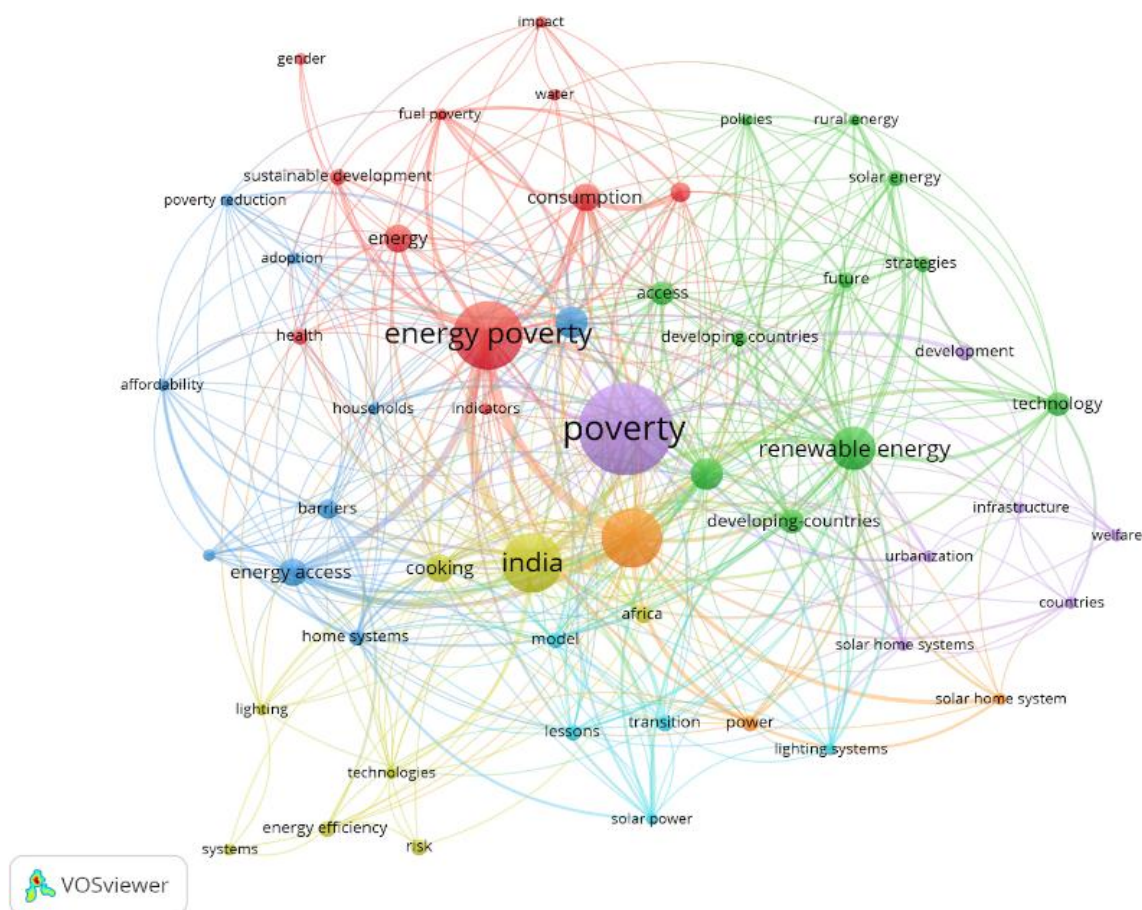


Figure 2. Cluster analysis for poverty and lighting (“lighting” AND “poverty”)

2. CASE OF STUDY

The San Sebastian neighborhood is located in Manizales, a municipality in Colombia. The neighborhood has been selected as a case study, since its community presents socioeconomic characteristics that place it as a vulnerable population. The project has been developed as social interest housing subsidized by the government in part for those families that earn less than two minimum monthly salaries (about US \$300 dollars). Given these characteristics, social organizations have advanced housing plans so that the community can have its own home. These plans have included constructions of two-family housing and apartment buildings in horizontal property. The buildings inhabited by the community with which the present project has been worked on, to assess the social impact that a photovoltaic lighting system can have on the resignification of the common spaces of the constructions. The construction method as shown in Figure 3 allows four families to live together on one floor, of which only one is in charge of lighting the common area as shown in Figure 4.

The lighting in these areas is poor and not independent of the internal power grid of the departments. This generates inconveniences among neighbors, since the owner of the apartment to which the external lighting is connected experiences an increase in his monthly energy consumption, and therefore decides to suspend the operation of the lighting, thus generating dark and unsafe common spaces, and an increase in the rates of insecurity.

As a way to contribute to the solution of a social conflict, and to the resignification of spaces, it was decided to implement an autonomous photovoltaic lighting system, to guarantee illuminated and safe spaces for the community. During the development, the community has been included, making a community design, which stimulates the appropriation of the system for the benefit of the community, achieving integration of the neighbors and improving the quality of life.

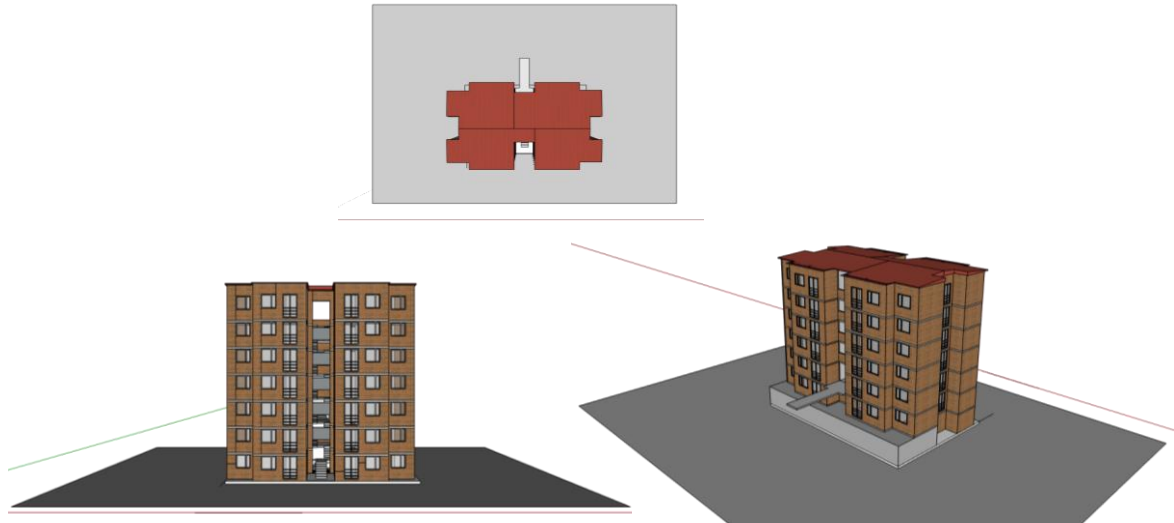


Figure 3. Construction of buildings where the community resides. Different perspectives

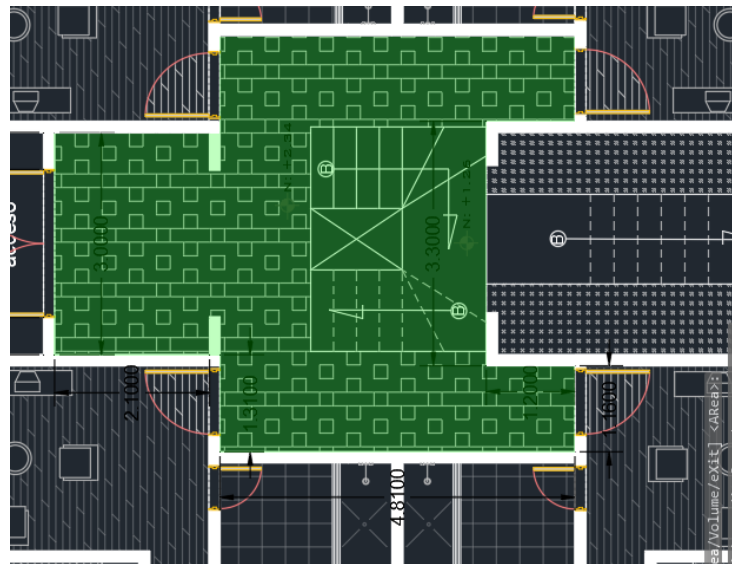


Figure 4. Determination of the area to be illuminated per floor

3. RESULTS AND DISCUSSION

For the design of the system that allows to contribute in the solution of the social conflict, we apply the methodology of participative research participatory action research (PAR) [19], which allows to take into account the culture, the socioeconomic conditions, the citizen participation, aspects that have been considered in studies for the design of renewable energy systems, such as [20], and additionally allows empowering local actors as they become active stakeholders in projects [21]-[23], the previous aspects were reflected in the methodological process addressed in this study and are shown in Figure 5.

During the sessions with the community, it was possible to carry out the planimetry work to establish the common area that should be intervened, in Figure 4 it is observed, highlighted in green, this area. Based on the area that should be illuminated, simulations were made to establish the optimal characteristics of the lighting system, considering that parameters such as the maximum power point (MPP) of the panel is sensitive to weather conditions [24]-[28] and partial shading conditions that may be generated by the building structure itself [29]. Given the above, and considering that the design had to be economic, the characteristics of the solar panels had to be defined in such a way that they would provide sufficient power according to the local daily characteristics of solar radiation and ambient temperature, and on the other hand

a storage system that would allow the energy to be stored for use at night. In this way, and considering the total area to be illuminated by each floor, and the total number of floors that should be illuminated, in Table 1 it is possible to observe the elements of the system that was defined to be installed. Table 2 shows number of homes covered by the solar lighting system.

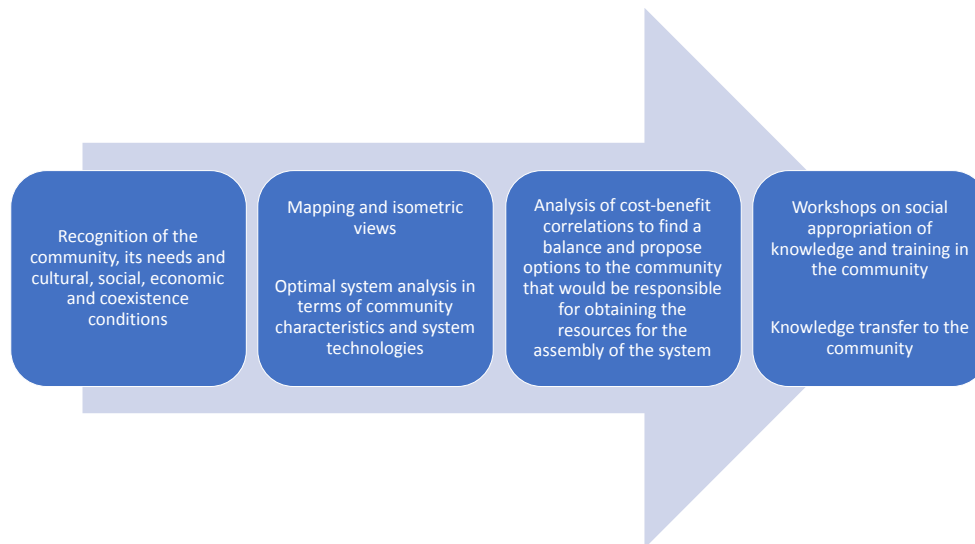


Figure 5. Social design methodology applied

Table 1. System elements

Item	Parameters	Quantity	Cost (USD)
Solar panel	Polycrystalline Solar Panel	2	340
Controller		2	144
Battery	12V 55Ah	2	231
Illumination	Led tape with heatsink	12	102
Pipeline EMT		8 units de 3 m	30
Copper wire 12AWG		30 m	33
Total			880

Table 2. Number of homes covered by the solar lighting system

Floor	Number of homes covered	Illuminated common area
Sub 1	2	29,22 m ²
1	4	29,22 m ²
2	4	29,22 m ²
3	4	29,22 m ²
4	4	29,22 m ²
5	4	29,22 m ²
TOTAL	22	175,3 m ²

Table 1 shows a total cost of the system of US \$880, assuming that on each floor residents currently have 25W energy-saving bulbs installed and that the lighting is turned on an average of 8 hours per day, the daily consumption is 0.200 kW and knowing that the community pays a value of US \$ 0.06 per kW, the current monthly cost of energy consumption for each floor is US \$ 18, and in total for the entire building is US \$ 108. With the above data, it is projected that in a time of approximately 8 months, the community has recovered the investment made in the system.

On social impact results, by re-dimensioning social actions and practices, which mediated by pedagogy allowed subjects to be approached according to their particularities, as part of the findings, it was possible to demonstrate that in a community in basic socioeconomic conditions, citizen participation in political and regulatory issues is almost nil, being all passive subjects in the decisions and the dynamics of the city, most of the social actors who were part of the initiative have independent jobs, becoming in their

majority the "vital minimum" which from the state's point of view is more than sufficient, an affirmation from which one has a distance that differs from the official reading.

The generative dialogue allowed a horizontal approach to people, while they were willing and interested in making their space a much more pleasant place where they could think and act differently. As part of the results, we were able to build pedagogical strategies based on the neuro-pedagogical, as was the case of the use of the image as a provocation, inspiring source of topics associated with coexistence, the agreement, the latter as a pretext to promote the construction of interactions between members of the community and with which they managed to overcome social conflicts using the agreement to reach decision making in order to achieve common interests.

Another important result was the use of information and communication technologies as tools in this case audiovisual that allowed a better familiarization with the topics, thus complementing the dialogues and workshops conducted with the subjects co-participants, social leaders and the community in general. The work focused on the development of emotional intelligence, coexistence and self-care as axes that cross the dynamics in community.

The co-design, favored the functionality of a community space in architectural perspective, coupled with it, this process enabled as a pretext the meeting of the inhabitants of residential units, participating with their opinion of what was the most appropriate use for such common spaces and other issues in which such space could serve for other agreements and activities.

4. CONCLUSION

In this article, the development and implementation of a photovoltaic lighting system was presented as a way to re-signify common spaces and positively impact the social conflicts that arise in a vulnerable community. It is demonstrated from the literature, the importance of electricity and lighting in the strengthening of the social fabric, damaged by lack of electricity or poor lighting systems in vulnerable communities in developing countries such as where the study was conducted.

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